Environment and Natural Resources Trust Fund
2016 Request for Proposals (RFP)

Project Title: **ENRTF ID: 058-B**

Forest to Potatoes Conversion and Sustainable Water Use

Category: B. Water Resources

Total Project Budget: $ 286,658

Proposed Project Time Period for the Funding Requested: 3 years, July 2016 to June 2019

Summary:

We will measured and model threats to water quantity and quality under forest to potato conversion in north-central Minnesota, and distribute tools useful to stakeholders for sustainable water resource management.

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Sponsoring Organization: U of MN

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Location

Region: Central, NW

County Name: Becker, Beltrami, Cass, Clay, Clearwater, Douglas, Grant, Hubbard, Mahnomen, Morrison, Otter Tail, Polk, Pope, Red Lake, Stearns, Stevens, Traverse, Wilkin

City / Township:

Alternate Text for Visual:

Forest to potato conversion has been widespread in north Central Minnesota, and 570,000 has good potential for conversion. Conversion alters groundwater recharge, and may carry pollutants to groundwater.

_____ Funding Priorities	_____ Multiple Benefits	_____ Outcomes	_____ Knowledge Base
_____ Extent of Impact	_____ Innovation	_____ Scientific/Tech Basis	_____ Urgency
_____ Capacity Readiness	_____ Leverage	_____ TOTAL	_____%

I. PROJECT STATEMENT

Forest to potato conversion and combined fertilizer/pesticide/irrigation (chemigation) is a threat to both water quantity and quality in north-central Minnesota. Although abundant rainfall suggests a water surplus, we risk repeating the history of Wisconsin's Central Sands potato region. There, in spite of high rainfall, conversion to potatoes and chemigation has dried rivers and lakes and polluted groundwater. Threats here include:

- Over 50,000 acres of forest have been converted to crops in north-central Minnesota since 2006, with potatoes accounting for the largest share, almost 10% of suitable forest in the affected watersheds.
- Approximately 570,000 acres are suitable for conversion from forests to potatoes, offering economic development, to be balanced against potentially damage surface and groundwater sources.
- We have very poor estimates of the increase in water use by potatoes and the forests they replace, and so we can't predict changes in groundwater recharge, which equals the amount of rainfall minus runoff and evaporation. Water quality is directly related to changes in water quantity, because recharge flow carries chemigation pollutants to groundwater; we need better measurements to protect grounwater.

Our specific project goals are to:

1) Measure water balance, particularly key missing information on evaporation, to estimate effects of forest to potato conversion on groundwater recharge and groundwater quality,
2) Build greatly improved methods that help farmers, foresters, and policymakers estimate changes in groundwater recharge and pollution due to forest-crop conversion, and
3) Promote these methods through in-person and web-based teaching and tools.

We will distribute these through training, publications, and websites targeting key stakeholders. This project will help Minnesota citizens, businesses, and governments manage trade-offs between water extraction and use, recharge, and water-based ecosystem services.

II. PROJECT ACTIVITIES AND OUTCOMES

Activity 1: *Water input/output measurement system fabrication, testing, quality control, deployment, and data collection.* **Budget: $153,994**

We will use greatly improved methods (eddy flux) to measure changes in water loss with conversion from forest to potatoes in northern and central Minnesota. Estimates today are based on old, inaccurate models primarily because evaporation had been difficult to measure. We have 10+ years of experience with eddy flux, but these new, much improved measurements have not been collected in Minnesota on potatoes or the target forest types. We will work with farmers and foresters to measure water inputs and losses over three full years.

Outcome	Completion Date
1. Site selection, flux system assembly, field deployment	*Sept. 1, 2016*
2. First field season measurements complete	*Nov. 15, 2016*
3. Second field season measurements complete	*Nov. 15, 2017*
5. Third season growing season measurement completed	*Nov. 15, 2018*

Activity 2: *Water balance estimates, model development* **Budget: $54,550**

We will combine measurements at field sites with local and statewide weather and soils data to create robust models of the change in water use with forest to potatoes conversion. We will develop methods based on these and widely-available weather data for user-friendly tools for evaporation and recharge, irrigation forecasting, and water loss calculators.

Outcome	Completion Date
1. Quality control on system function, first year's measurements, initial water flux estimates.	*April 1, 2017*
2. Improved estimates, completion of first water balance models, 2-year data	*April 1, 2018*
3. Final model developed, tested, documented, integrating regional weather, landcover data	*June 30, 2019*

Activity 3: *Model deployment, training, technology transfer* **Budget: $78,114**

We will develop a set of tables and handbook summarizing changes in evaporation, groundwater recharge, and susceptibility to groundwater contamination based on local soil conditions, chemigation rates and additives, and climate. We will integrate our models into web-based systems that access real-time weather data to predict adequate irrigation amounts and associated impacts on groundwater. We will organize workshops with key stakeholders to familiarize them with the tools capabilities and utility.

Outcome	Completion Date
1. Web- and broad-area model development, climate data assembly	*April 1, 2017*
2. Improved estimates, completion of first water balance models, 2-year data	*April 1, 2018*
3. Final model developed, tested, documented, integrating regional weather, landcover data	*June 30, 2019*

III. PROJECT STRATEGY

A. Project Team/Partners

Project science will be carried out by Drs. Tim Griffis, Department of Soil, Water, and Climate, and Paul Bolstad, Forest and Natural Resource Management, of the University of Minnesota, Twin Cities. They will be responsible for site selection, system development and deployment, quality control, analysis, model development, and results dissemination. They will coordinate work with agriculture and forest managers and scientists, including Dr. Randall Kolka of the USFS Marcell Experimental Forest, and Minnesota Area II Potato Growers Association (MN-PGA) for site selections, measurements, desirable products and outcomes, and dissemination strategies. Work will be coordinated with the MN DNR, Division of Waters, and the MN-PGA, partnering to present workshops on results, water use rates, and tools to producers, regional and local hydrologists, and water resource planners.

B. Project Impact and Long-Term Strategy

Our long-term strategy is to better develop the science and management of Minnesota water resources, and support sustainable water use. Water underpins much of Minnesota's economy, with agricultural production and first-level processing generating more than 150,000 jobs and $25 billion, and water-based tourism adding up to a third more. Work over the past decade by our groups has quantified water balance in corn, soybeans, alfalfa, prairie, and mature maple-hemlock forests, providing a basis for estimating long-term water sustainability under those systems. Past work focused on southern Minnesota, and has been funded by research grants from the National Science Foundation, US Department of Agriculture, and by the Minnesota Corn Growers Association. We have integrated results into the leading national weather/crop modeling system, and developed short-term water use and plant water demand prediction tools, similar to weather forecasts. We lack measurements and models for many important crops and landcovers, which must be measured to address many specific problems facing Minnesota's water management.

While the proposed measurements are part of a broader goal of quantifying water balance for all important Minnesota landcovers, this project is self-contained in focusing on types (potatoes, mixed forests, wetlands) that will help solve current as well as future problems. Improved measurements in potatoes vs. forests will guide current conversion-related permitting, and eddy flux measurements in weltand and lake systems may identify how local infiltration zones or other mitigation strategies may offset losses under forest conversion.

C. Timeline Requirements

The proposed project includes three complete measurement seasons, most likely sufficient to provide accurate estimates and models. Water use varies by weather and extreme conditions, e.g. droughts or rainy periods, but the likelihood of three-year extreme events is low, and the normal yearly variation, e.g., from spring to late summer, provides most of the range of water demand within most three-year periods. Our timeline for analysis and presentations extends approximately six months beyond the 36-month budget period, to allow integration of final-year measurements into our analysis, and workshops for farmers, hydrologists, and water planners.

2016 Detailed Project Budget

Project Title: *Forest to Potatoes Conversion and Sustainable Water Use*

INSTRUCTIONS AND TEMPLATE (1 PAGE LIMIT)

Attach budget, in MS-EXCEL format, to your "2016 LCCMR Proposal Submission Form".

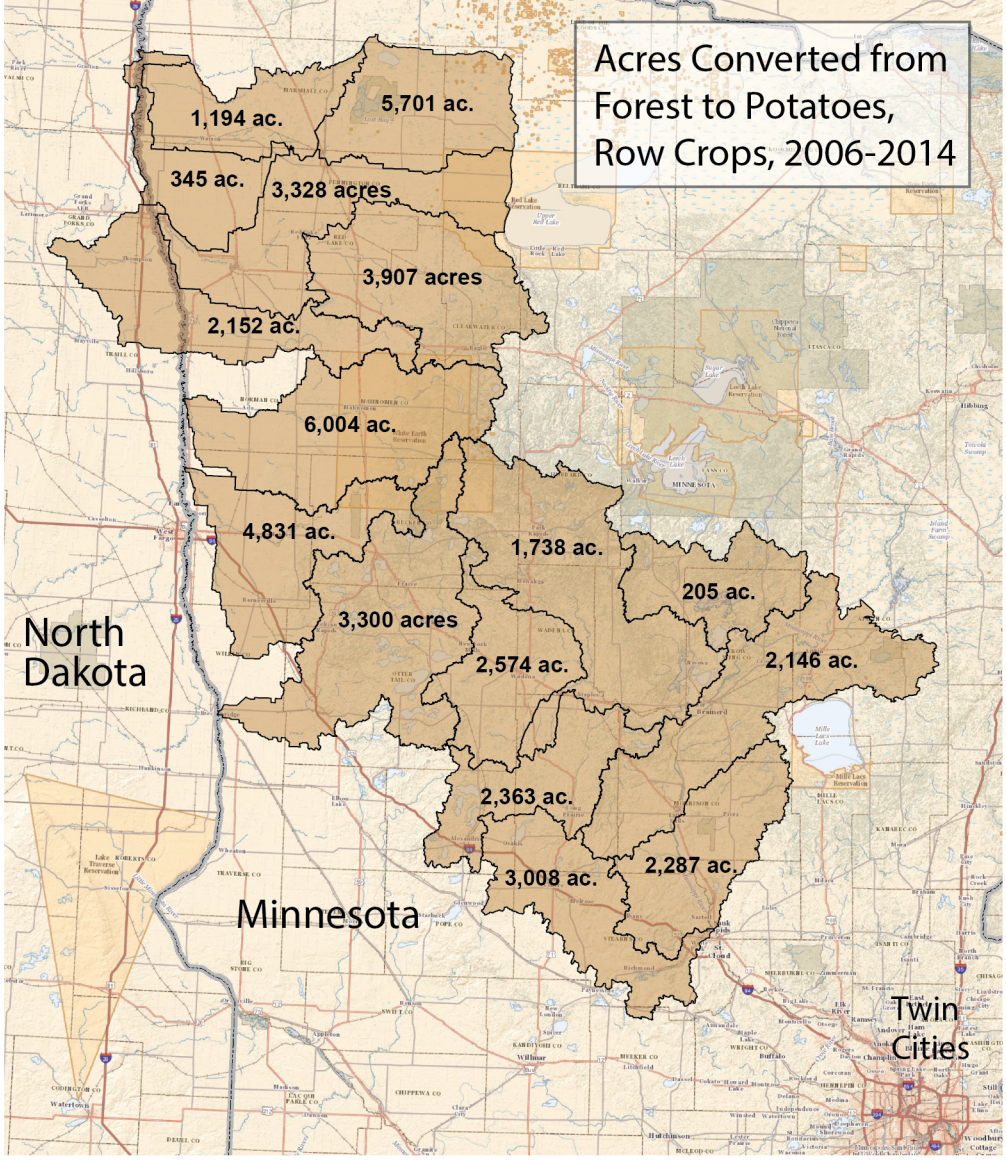
(1-page limit, single-sided, 10 pt. font minimum. Retain bold text and DELETE all instructions typed in italics. ADD OR DELETE ROWS AS NECESSARY. If budget item row is not applicable put "N/A" or delete it. All of "Other Funds" section must be filled out.)

IV. TOTAL ENRTF REQUEST BUDGET *[Insert # of years for project]* **years**

BUDGET ITEM *(See "Guidance on Allowable Expenses", p. 13)*	**AMOUNT**
Personnel:1) For system deployment & data acquisition, QC, 1 person, half-time all three years, total of 1.5 person-years of field and laboratory technicians, $44.8k/year salary, 27.4% fringe, half-time for all three years of proposal. These complicated systems include high-precision sensors, a ruggedized field data logging/computer, and complex calibration and troubleshooting, as well as practical knowledge in tower construction, cement work, and tool use.	$ 85,612
Personnel: 2) For analysis and model development, 1 Jr. Scientist, $40,8k/yr salary, 33.7% fringe, 50% time for years 1 & 2 of the project. Advance mathematical, statistical, and computer skills required to evaluate and process complex high frequency data.	$ 54,550
Personnel: 3) for training, web model development, training, training materials, 1 Jr. Scientist, $40,8k/yr salary, 33.7% fringe, 65% years 2&3 of project	$ 70,914
Equipment/Tools/Supplies: *Two eddy flux measurement systems, to be assembeled from components primarily ordered from Campbell Scientific. Each includes 1 hardened field computer/logger ($1,550), a sonic anemometer ($8,150), a Krypton Hygrometer ($6,064), telemetry radio and equipment ($1,200), temperature, humidity, precipitation, and cup anemometer ($2,442), a net radiometers ($2,026), mass storage, an enclosure, cables, mounting hardware and tower, and logging software to bring the total to $27,223.60 per system, or $54,447 for two, one each in potatoes and forests.*	$ 54,447
Travel: Field/lab technician t*ravel to and from research sites for equipment setup, maintenance, and repair, 22 trips @ $600 each, travel by scientist/trainer to/from tool training/forums, 8 trips, travel, perdiem, 2 nights in a hotel, each trip @$400*	$ 16,400
Additional Budget Items: *This is field supplies and expenses, including calibration gasses, water sample chemical analysis, dessicant packs for logger enclosures, equipment reclalibration against national standards, misc. bolts, hardware, cement, and other materials for measurement site preparation and setup, and data transmission/storage costs, web development costs.*	$ 4,735
TOTAL ENVIRONMENT AND NATURAL RESOURCES TRUST FUND $ REQUEST =	$ 286,658

V. OTHER FUNDS *(This entire section must be filled out. Do not delete rows. Indicate "N/A" if row is not applicable.)*

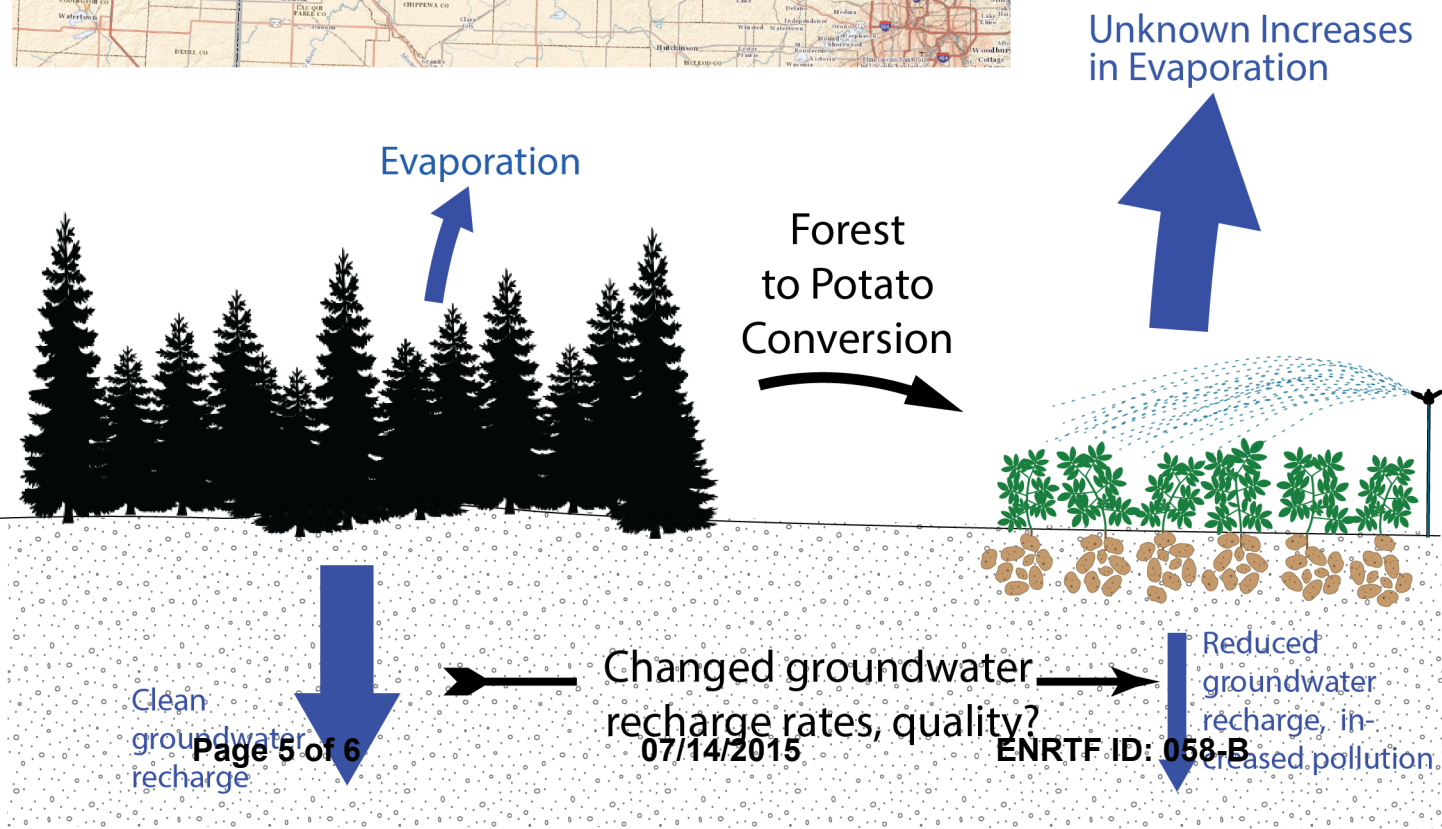
SOURCE OF FUNDS	**AMOUNT**	**Status**
Other Non-State $ To Be Applied To Project During Project Period: *Funds appropriated on a current US Department of Agriculture Grant*	$ 22,100	*Secured*
Other State $ To Be Applied To Project During Project Period: *None*	NA	*NA*
In-kind Services To Be Applied To Project During Project Period: *1 month faculty time on project for Bolstad, on a nine-month appointment to the University of Minnesota. His summer time may be charged to projects, but won't be in this case to this project.*	$ 11,000	*Secured*
Funding History: *We have received over $2million in research funding over the past decade in water quantity, quality, and water balance measurement and modeling studies. This includes competitive grant funds from the U.S. Depatment of Agriculture, the National Science Foundation, the Minnesota Corn Growers Association, the Department of Energy, and NASA. Griffis and Bolstad combined have more than 140 scientific papers published in forest and crop system science and management, and Griffis is the editor of the primary crop and forest environmental journal in North America.*	$2million	Secured for past projects
Remaining $ From Current ENRTF Appropriation: *None*	NA	*NA*



Over 50,000 acres, or about 10% of the total forest, have been converted to irrigated crops in the shaded watersheds, to the left, with conversion to potatoes most common.

Chemigation can deplete and pollute aquifers.

We need to measure evaporation better to estimate groundwater recharge and contamination, and define sustainability.



Project Manager Qualifications

Dr. Tim Griffis is a professor in the Department of Soil, Water, and Climate at the University of Minnesota (www.biometeorology.umn.edu). He has been a faculty member at the University of Minnesota since 2002. He teaches courses in micrometeorology and climatology and specializes in boundary-layer meteorology and biometeorology. His research involves the use of boundary layer theory, isotope techniques, and land-atmosphere modeling to study atmospheric transport processes, water budgets, and the greenhouse gas budgets of natural and managed ecosystems at the field to regional scales. He has managed several large scale projects funded by the National Science Foundation, Department of Energy, and United States Department of Agriculture. In the proposed project he will oversee all of the measurement and modeling activities and will ensure that all reporting requirements are met and the project stays on schedule.

Professional Preparation

2002	NSERC Postdoctoral Fellow, Biometeorology, Univ, of British Columbia, BC, Canada
2000	Ph.D., School of Geography and Earth Sciences, McMaster University, ON, Canada
1995	B.Sc., Physical Geography, Brock University, ON, Canada

Appointments

2012-	Professor, Department of Soil, Water, and Climate, University of Minnesota- Twin Cities, USA
2012	Visiting Fellow: School of Forestry and Environmental Studies, Yale University, New Haven, Connecticut, USA
2006-2012	Associate Professor, Department of Soil, Water, and Climate, University of Minnesota-Twin Cities, USA
2002-2006	Assistant Professor, Department of Soil, Water, and Climate, University of Minnesota-Twin Cities, USA
2000-2002	Natural Sciences and Engineering Research Council Postdoctoral Fellow, Biometeorology and Soil Physics Group, University of British Columbia, Canada
1997-2001	Research Assistant, Canadian Land-Atmosphere Surface Scheme Project, Meteorological Service of Canada

Synergistic activities:

- American Meteorological Society – Board Member on Atmospheric Biogeosciences
- Co-Director of Graduate Studies in Land and Atmospheric Science, Dept. of Soil, Water, and Climate, University of Minnesota, 2009-present
- Member of the National Ecological Observatory Network (NEON Inc.)- Fundamental Instrument Unit, Working Group, 2009-present
- Associate Editor, Agricultural and Forest Meteorology, 2008 to present
- Associate Editor, Journal of Geophysical Research-Biogeosciences, 2007 to 2011

Organizational Description

The proposed research will be conducted in the Department of Soil, Water, and Climate and Forest Resources at the University of Minnesota. The field research will take place at various forest and agricultural sites with an emphasis on north central Minnesota. All of the proposed data analyses and modeling activities will rely on the University of Minnesota Supercomputing Institute (https://www.msi.umn.edu/). All project personnel are members of the Land and Atmospheric Science program of the University of Minnesota. We will recruit one technician and one research scientist to assist with the data analyses and modeling activities proposed in this study. Personnel will be mentored by Griffis and Bolstad. All of the research will be performed within the guidelines of the University of Minnesota's Responsible Conduct of Research (RCR).